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TECHNICAL REPORT 3091

TRUE AVERAGE SIZE
OF A
FRAGMENT BETWEEN ANY CHOSEN LIMITS

SIDNEY KRAVITZ
LOUIS WIESENFELD

Munitions Command

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PICATINNY ARSENAL
DOVER, NEW JERSEY

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BY

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AMCMS 5522.11.556x01 JULY 1963

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SECTION I

INTRODUCTION

It is customary to group various fragment weights into discrete ranges such as 1-2 grains, 2-5 grains and 5-10 grains when evaluating lethal effectiveness. Then it is assumed that the average fragment weight in each grouping is the arithmetic average of the upper and lower limits of the group. For example, the average for the range 2-5 grains, would be taken as 3-1/2 grains. Now it is known that the distribution of fragment weights for an exploding shell follows Mott's distribution in which the smaller the fragment the greater is their number. Consequently, the true average in each grouping is somewhat less than the arithmetic average, due to the excess number of fragments in the lower half of the grouping.

The purpose of this report is to develop a method for finding the correct average in each grouping assuming Mott's distribution is correct.

SECTION II

SUMMARY

The objective of this study was to develop a method for determining the correct average fragment size, between any chosen limits, of a range of sizes. Ordinarily, the arithmetic average of the lower and upper limits of a grouping is assumed to be the average fragment weight of that group. According to Mott's distribution, the smaller the fragment, the greater is the number of fragments. Therefore the arithmetic average of any grouping of fragment sizes would be larger than the true average. By writing an expression for the average size of a fragment in an interval between $\underline{m}$ and $\underline{m + \Delta m}$ (where Δm is small), allowing Δm to approach a limit of zero, and substituting Mott's equation in the resulting differential and integrating, we get a generalized expression for the true average size of a fragment between any chosen limits. A numerical example is illustrated in Table 1. A listing of values in Table 2 readily solves the derived equation.

SECTION III

CONCLUSION

Where fragments are distributed according to Mott's Law, the arithmetic average of the high and low fragment sizes of a group is higher than the true average for the group. An equation is derived from which the true average can be calculated.

SECTION IV

RECOMMENDATION

Taking an arithmetic average of the high and low fragment sizes of a group should be discontinued. Instead, the average fragment size should be found from the equation derived in this study.

SECTION V

STUDY

DERIVATION OF THE EQUATIONS

Mott's equation (Reference 1) for the distribution of fragment weights in an exploding shell is:

$$N(m) = \left(\frac{M}{2\mu}\right) e^{-\left(\frac{m}{\mu}\right)^{1/2}} \tag{1}$$

where N(m) is the number of fragments greater than fragment weight m. M is the total weight of fragmenting metal. 2μ is the average fragment weight.

Now in an interval between m and m + Δ m, the number of fragments is N(m) - N(m + Δ m) and, if the interval is small, their average size is m + $\frac{\Delta m}{2}$. Thus the total weight is $\left[N(m) - N(m+\Delta m)\right]\left[m + \frac{\Delta m}{2}\right]$, and in a range from m = A to m = B, the true average fragment size is:

$$m_{AV} = \frac{\sum_{m=A}^{m=B} \left[N(m) - N(m+\Delta m)\right]\left[m + \frac{\Delta m}{2}\right]}{N(A) - N(B)} \tag{2}$$

A numerical example illustrating the use of this equation is in Table I. Here the average in an interval between A = 2 grains to B = 5 grains is found to be 3.30 grains. The average fragment for the entire shell is 2μ = 9.834 grains. Δm is chosen as 0.2 grains in this example.

Equation (2) may be rewritten as:

$$m_{AV} = \frac{\sum_{m=A}^{m=B} - \left[\frac{N(m+\Delta m) - N(m)}{\Delta m}\right]\left[m + \frac{\Delta m}{2}\right]\Delta m}{N(A) - N(B)} \tag{3}$$

If we allow Δ m to approach a limit of zero then:

$$m_{AV} = \int_A^B -\left(\frac{dN(m)}{dm}\right)(m)\,dm \Big/ \left[N(A) - N(B)\right] \tag{4}$$

$$\frac{dN(m)}{dm} = \frac{d\left(\frac{M}{2\mu}\right)e^{-\left(\frac{m}{\mu}\right)^{1/2}}}{dm} = -\left(\frac{M}{2\mu}\right)\left(\frac{1}{2}\right)\left(\frac{m}{\mu}\right)^{-1/2}\frac{1}{\mu}$$

Thus

$$m_{AV} = \int_A^B \left(\frac{1}{2}\right)\left(\frac{M}{2\mu}\right)\left(\frac{m}{\mu}\right)^{1/2} e^{-\left(\frac{m}{\mu}\right)^{1/2}} dm \Big/ \left[N(A) - N(B)\right] \tag{5}$$

Let
$$\left(\frac{m}{\mu}\right) = x^2$$
$$dm = 2\mu x\,dx$$
$$\left(\frac{m}{\mu}\right)^{1/2} = x$$

$$m_{AV} = \int_{\left(\frac{A}{\mu}\right)^{1/2}}^{\left(\frac{B}{\mu}\right)^{1/2}} \left(\frac{1}{2}\right)\left(\frac{M}{2\mu}\right) x e^{-x}\, 2\mu x\,dx \Big/ \left[N(A) - N(B)\right]$$

$$= \frac{M}{2}\int_{\left(\frac{A}{\mu}\right)^{1/2}}^{\left(\frac{B}{\mu}\right)^{1/2}} x^2 e^{-x}\,dx \Big/ \left[N(A) - N(B)\right]$$

$$= \frac{\mu\left[e^{-\left(\frac{A}{\mu}\right)^{1/2}}\left(\left(\frac{A}{\mu}\right) + 2\left(\frac{A}{\mu}\right)^{1/2} + 2\right) - e^{-\left(\frac{B}{\mu}\right)^{1/2}}\left(\left(\frac{B}{\mu}\right) + 2\left(\frac{B}{\mu}\right)^{1/2} + 2\right)\right]}{e^{-\left(\frac{B}{\mu}\right)^{1/2}} - e^{-\left(\frac{A}{\mu}\right)^{1/2}}} \tag{6}$$

Using $A = 2$, $B = 5$ and $\mu = \frac{9.834}{2} = 4.917$ grains gives $m_{AV} =$ 3.30 grains, which verifies the numerical calculation in Table I.

If $$f(x) \equiv e^{-x^{1/2}} \tag{7}$$

And $$g(x) \equiv f(x)\left[x + 2x^{1/2} + 2\right] \tag{8}$$

Then

$$m_{AV} = \frac{\mu\left[g\left(\frac{A}{\mu}\right) - g\left(\frac{B}{\mu}\right)\right]}{\left[f\left(\frac{B}{\mu}\right) - f\left(\frac{A}{\mu}\right)\right]} \tag{9}$$

Table II gives f and g as functions of x.

REFERENCES

1. Ordnance Engineering Design Handbook, Artillery Ammunition Series ORDP 20-245 Section 2, Design For Terminal Effects, May 1957.

APPENDIX

APPENDIX A

TABLES

TABLE I

NUMERICAL SOLUTION OF EQUATION (2) BETWEEN THE LIMITS OF 2 AND 5 GRAINS

m	m/μ	$(m/\mu)^{1/2}$	$e^{-(m/\mu)^{1/2}}$	$N(m)$	No. Of Fragments In Interval	Arithmetic Avg. In Interval
2.0	0.40675	0.63777	0.52846	1534		
					47	2.1
2.2	0.44743	0.66890	0.51227	1487		
					43	2.3
2.4	0.48810	0.69864	0.49728	1444		
					41	2.5
2.6	0.52878	0.72717	0.48326	1403		
					38	2.7
2.8	0.56945	0.75462	0.47024	1365		
					36	2.9
3.0	0.61013	0.78111	0.45790	1329		
					33	3.1
3.2	0.65080	0.80672	0.44632	1296		
					32	3.3
3.4	0.69148	0.83155	0.43539	1264		
					30	3.5
3.6	0.73215	0.85566	0.42499	1234		
					29	3.7

TABLE I (CONT'D)

m	m/μ	$(m/\mu)^{1/2}$	$e^{-(m/\mu)^{1/2}}$	$N(m)$	No. Of Fragments In Interval	Arithmetic Avg. In Interval
3.8	0.77283	0.87911	0.41516	1205		
					27	3.9
4.0	0.81350	0.90194	0.40580	1178		
					26	4.1
4.2	0.85418	0.92422	0.39685	1152		
					25	4.3
4.4	0.89485	0.94597	0.38829	1127		
					23	4.5
4.6	0.93553	0.96723	0.38014	1104		
					23	4.7
4.8	0.97621	0.98803	0.37232	1081		
					22	4.9
5.0	1.01688	1.00840	0.36480	1059		

$$\text{Avg. fragment size} = \frac{\text{total fragment wt. between 2 and 5 grains}}{\text{total No. of fragments between 2 and 5 grain}} = \frac{1566.1}{475} = 3.3$$

m = fragment wt. in grains
2μ = 9.834 grains = average fragment size for entire shell
N(m) = the number of fragments greater than fragment wt. m
M = 28,548 grains = total wt. of fragmenting metal
e = base of natural logarithm

TABLE 2

f AND g AS FUNCTIONS OF x FOR m/μ FROM 0.01 TO 5.00

m/μ	f	g	m/μ	f	g
0.01	0.90484	1.99969	0.41	0.52713	1.94543
0.02	0.86812	1.99915	0.42	0.52305	1.94374
0.03	0.84097	1.99848	0.43	0.51906	1.94204
0.04	0.81873	1.99770	0.44	0.51514	1.94034
0.05	0.79963	1.99685	0.45	0.51129	1.93862
0.06	0.78274	1.99592	0.46	0.50751	1.93691
0.07	0.76753	1.99493	0.47	0.50381	1.93518
0.08	0.75364	1.99389	0.48	0.50016	1.93345
0.09	0.74082	1.99280	0.49	0.49659	1.93172
0.10	0.72889	1.99167	0.50	0.49307	1.92998
0.11	0.71773	1.99050	0.51	0.48961	1.92823
0.12	0.70722	1.98929	0.52	0.48621	1.92648
0.13	0.69729	1.98805	0.53	0.48287	1.92472
0.14	0.68786	1.98678	0.54	0.47958	1.92296
0.15	0.67889	1.98548	0.55	0.47634	1.92120
0.16	0.67032	1.98415	0.56	0.47316	1.91943
0.17	0.66212	1.98279	0.57	0.47002	1.91766
0.18	0.65425	1.98142	0.58	0.46693	1.91588
0.19	0.64669	1.98002	0.59	0.46389	1.91410
0.20	0.63941	1.97860	0.60	0.46089	1.91232
0.21	0.63238	1.97716	0.61	0.45794	1.91053
0.22	0.62560	1.97570	0.62	0.45503	1.90874
0.23	0.61904	1.97423	0.63	0.45216	1.90695
0.24	0.61269	1.97273	0.64	0.44933	1.90515
0.25	0.60653	1.97122	0.65	0.44654	1.90336
0.26	0.60055	1.96970	0.66	0.44379	1.90155
0.27	0.59475	1.96816	0.67	0.44108	1.89975
0.28	0.58911	1.96661	0.68	0.43840	1.89794
0.29	0.58361	1.96505	0.69	0.43576	1.89614
0.30	0.57827	1.96347	0.70	0.43315	1.89432
0.31	0.57305	1.96188	0.71	0.43058	1.89251
0.32	0.56797	1.96028	0.72	0.42804	1.89070
0.33	0.56301	1.95867	0.73	0.42554	1.88888
0.34	0.55817	1.95704	0.74	0.42306	1.88706
0.35	0.55344	1.95541	0.75	0.42062	1.88524
0.36	0.54881	1.95377	0.76	0.41821	1.88342
0.37	0.54429	1.95212	0.77	0.41582	1.88159
0.38	0.53986	1.95046	0.78	0.41347	1.87977
0.39	0.53553	1.94879	0.79	0.41114	1.87794
0.40	0.53129	1.94711	0.80	0.40884	1.87612

TABLE 2 (CONT'D)

f AND g AS FUNCTIONS OF x FOR m/μ FROM 0.01 TO 5.00

m/μ	f	g
0.81	0.40657	1.87429
0.82	0.40432	1.87246
0.83	0.40210	1.87062
0.84	0.39991	1.86879
0.85	0.39774	1.86696
0.86	0.39560	1.86513
0.87	0.39347	1.86329
0.88	0.39138	1.86146
0.89	0.38930	1.85962
0.90	0.38725	1.85778
0.91	0.38522	1.85595
0.92	0.38321	1.85411
0.93	0.38123	1.85227
0.94	0.37926	1.85043
0.95	0.37731	1.84859
0.96	0.37539	1.84675
0.97	0.37348	1.84492
0.98	0.37160	1.84308
0.99	0.36973	1.84124
1.00	0.36788	1.83940
1.01	0.36605	1.83756
1.02	0.36424	1.83572
1.03	0.36244	1.83388
1.04	0.36067	1.83204
1.05	0.35891	1.83020
1.06	0.35716	1.82836
1.07	0.35544	1.82652
1.08	0.35373	1.82469
1.09	0.35203	1.82285
1.10	0.35035	1.82101
1.11	0.34869	1.81917
1.12	0.34705	1.81734
1.13	0.34541	1.81550
1.14	0.34380	1.81367
1.15	0.34219	1.81183
1.16	0.34060	1.81000
1.17	0.33903	1.80816
1.18	0.33747	1.80633
1.19	0.33592	1.80450
1.20	0.33439	1.80266
1.21	0.33287	1.80083
1.22	0.33136	1.79900
1.23	0.32987	1.79717
1.24	0.32839	1.79534
1.25	0.32692	1.79352
1.26	0.32547	1.79169
1.27	0.32402	1.78986
1.28	0.32259	1.78804
1.29	0.32117	1.78621
1.30	0.31976	1.78439
1.31	0.31837	1.78257
1.32	0.31698	1.78075
1.33	0.31561	1.77893
1.34	0.31424	1.77711
1.35	0.31289	1.77529
1.36	0.31155	1.77347
1.37	0.31022	1.77165
1.38	0.30890	1.76984
1.39	0.30759	1.76803
1.40	0.30629	1.76621
1.41	0.30500	1.76440
1.42	0.30372	1.76259
1.43	0.30245	1.76078
1.44	0.30119	1.75897
1.45	0.29994	1.75717
1.46	0.29870	1.75536
1.47	0.29747	1.75356
1.48	0.29625	1.75176
1.49	0.29504	1.74995
1.50	0.29383	1.74815
1.51	0.29264	1.74636
1.52	0.29145	1.74456
1.53	0.29027	1.74276
1.54	0.28910	1.74097
1.55	0.28794	1.73917
1.56	0.28679	1.73738
1.57	0.28565	1.73559
1.58	0.28451	1.73380
1.59	0.28338	1.73202
1.60	0.28226	1.73023

TABLE 2 (CONT'D)

f AND g AS FUNCTIONS OF x
FOR m/μ FROM 0.01 TO 5.00

m/μ	f	g	m/μ	f	g
1.61	0.28115	1.72845	2.01	0.24226	1.65839
1.62	0.28005	1.72666	2.02	0.24141	1.65667
1.63	0.27895	1.72488	2.03	0.24056	1.65496
1.64	0.27786	1.72310	2.04	0.23972	1.65324
1.65	0.27678	1.72132	2.05	0.23888	1.65153
1.66	0.27571	1.71955	2.06	0.23805	1.64982
1.67	0.27464	1.71777	2.07	0.23722	1.64812
1.68	0.27358	1.71600	2.08	0.23640	1.64641
1.69	0.27253	1.71423	2.09	0.23559	1.64471
1.70	0.27149	1.71245	2.10	0.23477	1.64300
1.71	0.27045	1.71069	2.11	0.23397	1.64130
1.72	0.26942	1.70892	2.12	0.23316	1.63961
1.73	0.26840	1.70715	2.13	0.23236	1.63791
1.74	0.26738	1.70539	2.14	0.23157	1.63621
1.75	0.26637	1.70363	2.15	0.23078	1.63452
1.76	0.26536	1.70186	2.16	0.23000	1.63283
1.77	0.26437	1.70010	2.17	0.22922	1.63114
1.78	0.26338	1.69835	2.18	0.22844	1.62945
1.79	0.26239	1.69659	2.19	0.22767	1.62777
1.80	0.26142	1.69484	2.20	0.22690	1.62608
1.81	0.26045	1.69308	2.21	0.22614	1.62440
1.82	0.25948	1.69133	2.22	0.22538	1.62272
1.83	0.25852	1.68958	2.23	0.22463	1.62104
1.84	0.25757	1.68784	2.24	0.22388	1.61937
1.85	0.25662	1.68609	2.25	0.22313	1.61769
1.86	0.25568	1.68434	2.26	0.22239	1.61602
1.87	0.25475	1.68260	2.27	0.22165	1.61435
1.88	0.25382	1.68086	2.28	0.22092	1.61268
1.89	0.25290	1.67912	2.29	0.22019	1.61101
1.90	0.25198	1.67738	2.30	0.21946	1.60935
1.91	0.25107	1.67565	2.31	0.21874	1.60769
1.92	0.25016	1.67391	2.32	0.21802	1.60603
1.93	0.24926	1.67218	2.33	0.21731	1.60437
1.94	0.24837	1.67045	2.34	0.21660	1.60271
1.95	0.24748	1.66872	2.35	0.21589	1.60105
1.96	0.24660	1.66700	2.36	0.21519	1.59940
1.97	0.24572	1.66527	2.37	0.21449	1.59775
1.98	0.24485	1.66355	2.38	0.21380	1.59610
1.99	0.24398	1.66183	2.39	0.21311	1.59445
2.00	0.24312	1.66011	2.40	0.21242	1.59280

TABLE 2 (CONT'D)

f AND g AS FUNCTIONS OF x
FOR m/μ FROM 0.01 TO 500

m/μ	f	g	m/μ	f	g
2.41	0.21174	1.59116	2.81	0.18706	1.52693
2.42	0.21106	1.58951	2.82	0.18651	1.52536
2.43	0.21038	1.58787	2.83	0.18595	1.52380
2.44	0.20971	1.58624	2.84	0.18540	1.52223
2.45	0.20904	1.58460	2.85	0.18485	1.52067
2.46	0.20837	1.58296	2.86	0.18431	1.51911
2.47	0.20771	1.58133	2.87	0.18376	1.51756
2.48	0.20705	1.57970	2.88	0.18322	1.51600
2.49	0.20639	1.57807	2.89	0.18268	1.51445
2.50	0.20574	1.57644	2.90	0.18215	1.51289
2.51	0.20509	1.57482	2.91	0.18161	1.51134
2.52	0.20445	1.57319	2.92	0.18108	1.50980
2.53	0.20380	1.57157	2.93	0.18055	1.50825
2.54	0.20316	1.56995	2.94	0.18003	1.50671
2.55	0.20253	1.56833	2.95	0.17950	1.50516
2.56	0.20190	1.56672	2.96	0.17898	1.50362
2.57	0.20127	1.56510	2.97	0.17846	1.50208
2.58	0.20064	1.56349	2.98	0.17795	1.50055
2.59	0.20002	1.56188	2.99	0.17743	1.49901
2.60	0.19940	1.56027	3.00	0.17692	1.49748
2.61	0.19878	1.55867	3.01	0.17641	1.49595
2.62	0.19817	1.55706	3.02	0.17590	1.49442
2.63	0.19756	1.55546	3.03	0.17540	1.49289
2.64	0.19695	1.55386	3.04	0.17490	1.49137
2.65	0.19635	1.55226	3.05	0.17440	1.48984
2.66	0.19574	1.55066	3.06	0.17390	1.48832
2.67	0.19514	1.54906	3.07	0.17340	1.48680
2.68	0.19455	1.54747	3.08	0.17291	1.48528
2.69	0.19396	1.54588	3.09	0.17242	1.48377
2.70	0.19337	1.54429	3.10	0.17193	1.48225
2.71	0.19278	1.54270	3.11	0.17144	1.48074
2.72	0.19220	1.54112	3.12	0.17096	1.47923
2.73	0.19161	1.53953	3.13	0.17047	1.47772
2.74	0.19104	1.53795	3.14	0.16999	1.47621
2.75	0.19046	1.53637	3.15	0.16951	1.47471
2.76	0.18989	1.53479	3.16	0.16904	1.47320
2.77	0.18932	1.53322	3.17	0.16856	1.47170
2.78	0.18875	1.53164	3.18	0.16809	1.47020
2.79	0.18819	1.53007	3.19	0.16762	1.46870
2.80	0.18762	1.52850	3.20	0.16715	1.46721

TABLE 2 (CONT'D)

f AND g AS FUNCTIONS OF x
FOR m/µ FROM 0.01 TO 5.00

m/µ	f	g	m/µ	f	g
3.21	0.16669	1.46571	3.61	0.14957	1.40744
3.22	0.16622	1.46422	3.62	0.14918	1.40602
3.23	0.16576	1.46273	3.63	0.14878	1.40460
3.24	0.16530	1.46124	3.64	0.14839	1.40319
3.25	0.16484	1.45976	3.65	0.14801	1.40177
3.26	0.16438	1.45827	3.66	0.14762	1.40036
3.27	0.16393	1.45679	3.67	0.14724	1.39895
3.28	0.16348	1.45531	3.68	0.14685	1.39754
3.29	0.16303	1.45383	3.69	0.14647	1.39613
3.30	0.16258	1.45235	3.70	0.14609	1.39472
3.31	0.16213	1.45087	3.71	0.14571	1.39332
3.32	0.16169	1.44940	3.72	0.14533	1.39192
3.33	0.16125	1.44793	3.73	0.14496	1.39052
3.34	0.16080	1.44646	3.74	0.14458	1.38912
3.35	0.16037	1.44499	3.75	0.14421	1.38772
3.36	0.15993	1.44352	3.76	0.14384	1.38633
3.37	0.15949	1.44206	3.77	0.14347	1.38493
3.38	0.15906	1.44059	3.78	0.14310	1.38354
3.39	0.15863	1.43913	3.79	0.14273	1.38215
3.40	0.15820	1.43767	3.80	0.14237	1.38076
3.41	0.15777	1.43622	3.81	0.14200	1.37937
3.42	0.15734	1.43476	3.82	0.14164	1.37799
3.43	0.15692	1.43331	3.83	0.14128	1.37661
3.44	0.15650	1.43185	3.84	0.14092	1.37522
3.45	0.15608	1.43040	3.85	0.14056	1.37385
3.46	0.15566	1.42895	3.86	0.14020	1.37247
3.47	0.15524	1.42751	3.87	0.13984	1.37109
3.48	0.15482	1.42606	3.88	0.13949	1.36972
3.49	0.15441	1.42462	3.89	0.13914	1.36834
3.50	0.15400	1.42318	3.90	0.13878	1.36697
3.51	0.15359	1.42174	3.91	0.13843	1.36560
3.52	0.15318	1.42030	3.92	0.13808	1.36423
3.53	0.15277	1.41887	3.93	0.13774	1.36287
3.54	0.15236	1.41743	3.94	0.13739	1.36150
3.55	0.15196	1.41600	3.95	0.13704	1.36014
3.56	0.15156	1.41457	3.96	0.13670	1.35878
3.57	0.15116	1.41314	3.97	0.13636	1.35742
3.58	0.15076	1.41171	3.98	0.13601	1.35606
3.59	0.15036	1.41029	3.99	0.13567	1.35471
3.60	0.14996	1.40886	4.00	0.13534	1.35335

TABLE 2 (CONT'D)

f AND g AS FUNCTIONS OF x
FOR m/μ FROM 0.01 TO 500

m/μ	f	g	m/μ	f	g
4.01	0.13500	1.35200	4.41	0.12246	1.29926
4.02	0.13466	1.35065	4.42	0.12217	1.29798
4.03	0.13433	1.34930	4.43	0.12188	1.29669
4.04	0.13399	1.34795	4.44	0.12159	1.29541
4.05	0.13366	1.34661	4.45	0.12130	1.29413
4.06	0.13333	1.34526	4.46	0.12101	1.29285
4.07	0.13300	1.34392	4.47	0.12073	1.29158
4.08	0.13267	1.34258	4.48	0.12044	1.29030
4.09	0.13234	1.34124	4.49	0.12016	1.28903
4.10	0.13201	1.33990	4.50	0.11987	1.28776
4.11	0.13169	1.33857	4.51	0.11959	1.28649
4.12	0.13136	1.33723	4.52	0.11931	1.28522
4.13	0.13104	1.33590	4.53	0.11903	1.28395
4.14	0.13072	1.33457	4.54	0.11875	1.28268
4.15	0.13040	1.33324	4.55	0.11847	1.28142
4.16	0.13008	1.33191	4.56	0.11820	1.28016
4.17	0.12976	1.33059	4.57	0.11792	1.27889
4.18	0.12944	1.32926	4.58	0.11764	1.27763
4.19	0.12913	1.32794	4.59	0.11737	1.27638
4.20	0.12881	1.32662	4.60	0.11710	1.27512
4.21	0.12850	1.32530	4.61	0.11682	1.27387
4.22	0.12819	1.32399	4.62	0.11655	1.27261
4.23	0.12788	1.32267	4.63	0.11628	1.27136
4.24	0.12757	1.32136	4.64	0.11601	1.27011
4.25	0.12726	1.32004	4.65	0.11574	1.26886
4.26	0.12695	1.31873	4.66	0.11547	1.26761
4.27	0.12664	1.31742	4.67	0.11521	1.26637
4.28	0.12634	1.31611	4.68	0.11494	1.26512
4.29	0.12603	1.31481	4.69	0.11468	1.26388
4.30	0.12573	1.31350	4.70	0.11441	1.26264
4.31	0.12542	1.31220	4.71	0.11415	1.26140
4.32	0.12512	1.31090	4.72	0.11389	1.26016
4.33	0.12482	1.30960	4.73	0.11362	1.25893
4.34	0.12452	1.30830	4.74	0.11336	1.25769
4.35	0.12422	1.30701	4.75	0.11310	1.25646
4.36	0.12393	1.30571	4.76	0.11284	1.25523
4.37	0.12363	1.30442	4.77	0.11259	1.25400
4.38	0.12334	1.30313	4.78	0.11233	1.25277
4.39	0.12304	1.30184	4.79	0.11207	1.25154
4.40	0.12275	1.30055	4.80	0.11182	1.25032

TABLE 2 (CONT'D)

f AND g AS FUNCTIONS OF x
FOR m/μ FROM 0.01 TO 5.00

m/μ	f	g
4.81	0.11156	1.24909
4.82	0.11131	1.24787
4.83	0.11106	1.24665
4.84	0.11080	1.24543
4.85	0.11055	1.24421
4.86	0.11030	1.24299
4.87	0.11005	1.24178
4.88	0.10980	1.24056
4.89	0.10955	1.23935
4.90	0.10931	1.23814
4.91	0.10906	1.23693
4.92	0.10881	1.23573
4.93	0.10857	1.23452
4.94	0.10833	1.23331
4.95	0.10808	1.23211
4.96	0.10784	1.23091
4.97	0.10760	1.22971
4.98	0.10736	1.22851
4.99	0.10712	1.22731
5.00	0.10688	1.22612

ABSTRACT DATA

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Picatinny Arsenal, Dover, New Jersey

TRUE AVERAGE SIZE OF A FRAGMENT BETWEEN ANY CHOSEN LIMITS

Sidney Kravitz, Louis Wiesenfeld

Technical Report 3091, July 1963, 18pp, tables.
Unclassified report from the Artillery Ammunition Laboratory, Ammunition Engineering Directorate.

A method was developed for determining the correct average fragment size, between any chosen limits, of a range of sizes when evaluating lethal effectiveness.

When fragments are distributed according to Mott's Law, the arithmetic average of the high and low fragment sizes of a group is higher than the true average for the group. The true average can be calculated from the derived equation.

UNCLASSIFIED

1. Ammunition Fragments

I. Kravitz, Sidney
II. Wiesenfeld, Louis
III. Average fragment size

UNITERMS

Size
Determination
Calculation
Kravitz, Sidney
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